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News

Budget Boosts Overall Research But Cuts NOAA and USGS Funds

Science in general, and physical sciences in particular, show growth far above projected inflation in President Ronald Reagan's fiscal 1984 budget proposal. Total funding requested for all federal research and development, including facilities, is \$47 billion, up 17.2% over fiscal 1983, jumping hurdles over the 5% projected inflation rate. Defense R&D is slated to soar 29% to \$30.5 billion, while non-defense R&D would rise 0.4% to \$16.7 billion. Table 1 shows the proposed research and development budgets by major departments and agencies.

Basic research in fiscal 1984 would be increased 9.9% over the fiscal 1983 level (Table 2). The growth rate of basic research in agencies primarily supporting the physical sciences and engineering sciences is 5 times greater than in those primarily supporting the life sciences.

Of the four nondefense agencies most directly involved in geophysical research, the National Science Foundation (NSF) fared the best with an 18.1% increase; the National Aeronautics and Space Administration (NASA) budget rose 9.9%; and the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA) budgets fell 7% and 10%, respectively.

Congress now has the task of reviewing the President's budget request and, if Congress desires, to alter it. *Eos* will track the budget process through Congressional approval.

In the following analysis, numbers may not total because of rounding.

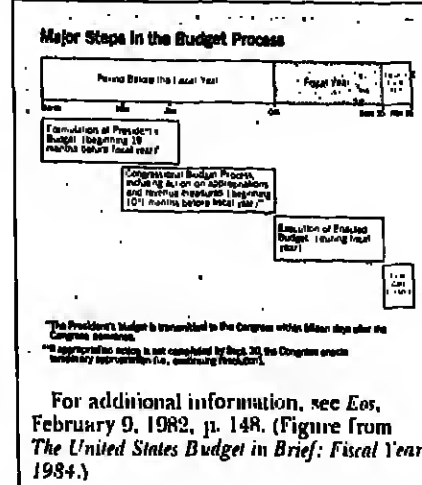


TABLE 2. Conduct of Basic Research

	Millions of Dollars			Percent Change		
	FY 82	FY 83	FY 84	83/82	84/83	84/82
Total Basic Research	5439	6025	6619	10.8	9.9	21.7
Agencies Supporting Primarily Life Sciences	2422	2678	2755	10.6	2.9	13.7
Agencies Supporting Primarily Physical Sciences & Engineering	3017	3347	3864	10.9	15.4	28.1

Source: Office of Management and Budget and Office of Science and Technology Policy.

NSF Budget Boosted

The fiscal 1984 budget request for NSF is \$1,292 billion, up 18.1% from fiscal 1983. Three major functions compose the NSF budget: research and related activities; scientific and engineering education activities; and special foreign currency appropriations. Research and related activities, accounting for more than 95% of the total NSF budget, got a 17.5% increase in the Reagan budget proposal. Science and engineering education got a 30% boost to \$99 million. In the special foreign currency category, the budget allocates \$2.6 million—roughly \$0.6 million less than the obligations for the current fiscal year; however, \$918,000 of the \$5.12 million that was budgeted in fiscal 1983 will be carried forward for fiscal 1984.

Under the budget proposal, the Directorate for Astronomical, Atmospheric, Earth, and Ocean Sciences (AAEO) would receive \$354.9 million, a 21.3% hike over fiscal 1983. Some of this increase, however, can be attributed to the inclusion of the ocean drilling programs in the directorate; the programs were previously under the aegis of the NSF director. Within the directorate, the astronomical sciences division got a 25.9% increase to \$70.3 million; the atmospheric sciences division got a 20.7% boost to \$90.0 million; earth sciences got a 23.5% increase to \$42.1 million; ocean sciences got a 9.8% increase to \$89.1 million; and the Arctic research program got a 19% increase to \$7.5 million. Funding for ocean drilling programs is scheduled to grow 59.4% to \$26.5 million.

Astronomical and Atmospheric Sciences

Highlights of AAEO's astronomical sciences division budget include \$2.2 million (up 45.7%) for solar system astronomy and \$9.8 million (up 46.5%) for astronomical instrumentation and development. The National Astronomy and Ionospheric Center has been budgeted for \$6.5 million from NSF (an increase of 21%) and \$315,000 from NASA, while the Kitt Peak National and Cerro-Tololo Inter-American observatories would receive \$21.9 million, up 17.5%. The National Radio Astronomy Observatory has been budgeted for \$20.6 million (an increase of 28.3%); the Sacramento Peak Observatory would receive \$2.6 million from NSF (up 23.8%) and \$415,000 from the Department of Defense. The emphasis on astronomy will allow for the implementation of the most important recommendations of the Astronomy Survey Committee of the National Academy of Sciences (NAS, May 18, 1982, p. 508).

Among the committee's priorities are improved instrumentation at universities and national centers, and feasibility and design studies on the Very Long Baseline Array. Within AAEO's atmospheric sciences division, the Global Atmospheric Research Program (GARP) has been marked for a 5% cut to \$4.8 million. Other programs budgeted for at least a 20% increase are atmospheric chemistry, climate dynamics, meteorology, and solar terrestrial research. The biggest increase—41.4%—goes to scientific computing at the National Center for Atmospheric Research (NCAR). NCAR is slated to get \$40.6 million, up 23.8%. At NCAR, the atmosphere

chemistry and aeronomy program will receive \$2.75 million (up 29.7%), while atmospheric technology will get \$7.51 million, an increase of 25.7%. Experimental meteorology is due to receive a 38.5% hike to \$5.4 million.

Earth and Ocean Sciences

Experimental and theoretical geophysics will get the largest increase in AAEO's earth sciences division—up 48.2% to \$3.7 million. Other major increases go to the experimental and theoretical geochemistry program (up 35.8% to \$7.2 million), the petrogenesis and mineral resources program (up 30% to \$5.2 million), and the mantle geochemistry program (up 29.0% to \$4 million). The increases throughout the division would permit year-round continental reflection profiling operations, upgrading of instrumentation, and a major research effort on the evolution and structure of continental crust.

Growth in the ocean sciences division will expand support for crustal studies, especially research that relates to the continental crust in the earth science division. The 59.4% increase in ocean drilling programs assumes a

continuation of the Deep Sea Drilling Project using the *Glomar Challenger*. A recently formed ad hoc advisory group on crustal studies, chaired by AGU President-elect Charles Drake, met as *Eos* went to press to review crustal research and to examine the long-term needs and priorities for ocean drilling in this light. Their recommendations could alter program proposals that NSF will present to the House Appropriations Committee on February 15. *Eos* will have more details in a few weeks.

Polar Programs

All but one of NSF's polar programs show growth beyond inflation. Glaciology programs, within the Arctic research division of AAEO, would get a hefty 77.8% increase to \$2 million. The Arctic oceanography program, however, would receive only 2.1% more money (to \$1.2 million) than it did in fiscal 1983 if the budget is passed as it stands. The fiscal 1984 budget request for the U.S. Antarctic Program (which is separate from AAEO) is \$102.1 million, an increase of \$18.9 million above the fiscal 1983 plan. Most of the increase goes for two capital investments: \$5.8 million to replace a large vehicle maintenance facility destroyed by fire in December 1981 and \$5 million to initiate a service life extension program on the two oldest LC-130 ski-equipped Hercules aircraft. In addition, Antarctic oceanography research will be boosted 14.8% and Antarctic glaciology research will be increased by 14.3%.

Compared to other directorates, AAEO and the U.S. Antarctic Program did reasonably well. The Directorate for Mathematical and Physical Sciences pursues totals \$364.3 million (up 21.5% from fiscal 1983); the Directorate for Biological, Behavioral, and Social Sciences is slated to receive \$223.8 million (up 17.5%); and the Directorate for Scientific, Technological, and International Affairs (better known as STIA) will receive \$56.8 million, down 16.7%.

Engineering

The Directorate for Engineering (allocated \$123 million, up 22%) includes the civil and environmental engineering programs, which encompass the activities of some AGU members. Within the civil and environmental engineering category, geotechnical engineering is slated for a 21.2% increase to \$4 million; structural mechanics will get a 27.8% increase to \$3.7 million; hydraulics, hydrology, and water resources engineering will receive an 18.9% increase to \$4.4 million; environmental and water quality engineering will get a 17.9% increase to \$3.3 million; and earthquake hazard mitigation will receive a 9.8% increase to \$19 million.

NOAA Funding Drops 10%

A close look at the President's fiscal 1984 budget request for NOAA reveals an overall program level of \$845.2 million; \$799.8 million of requested funds plus \$45.4 million in transfers. The \$799.8 million request represents an approximate 10% cut in funding, not including inflation—from the fiscal 1983 continuing resolution for NOAA.

Of the \$799.8 million requested, \$784 million

NASA Unit Sets Ambitious Course

After two decades of spectacular successes, planetary exploration has fallen upon hard times. It has been five years since a new spacecraft was launched toward the planets, and NASA has under current development only one planetary mission—Galileo, which will orbit Jupiter and probe its atmosphere in 1988. The intellectual challenge of understanding the planets and their common origin and evolution has not, of course, declined, and a great deal of exciting work is being accomplished using data (and samples) from past missions. But planetologists fear the demise of their discipline within a few years if momentum cannot be restored to NASA's program of planetary exploration.

One response to this crisis was the establishment in 1980 of a high-level scientific advisory committee to chart a course of planetary missions through the end of this century that would recapture the excitement of the 1960's and 1970's at a price consistent with the current constrained NASA budget. The Solar System Exploration Committee (SSEC), a subcommittee of the NASA Advisory Council, was originally chaired by John Naugle, then NASA Chief Scientist. In 1982 he was succeeded by Noel Hinners, then Director of the National Air and Space Museum and now Director of the NASA Goddard Space Flight Center (and also president of the AGU Planetary Science Section). For 1983, the chairmanship of the SSEC passes to David Morrison, Professor of Astronomy at the University of Hawaii and a former NASA Acting Deputy Associate Administrator for Space Science.

As it enters the final year of its charter, the SSEC is putting the finishing touches on a core program for planetary exploration through the year 2000. Acutely conscious of the fiscal constraints being imposed on space science today, the Committee has limited itself in this core program to missions with high scientific return at modest costs. In general, the committee will achieve these savings by avoiding the challenge of new technologies, such as those required for a Mars mobile lander or a comet sample return; it will rely instead on the proven capabilities of flybys, orbiters, and atmospheric probes. The committee will aim for further savings by a close and carefully planned spacing of missions to realize maximum investment and common operations. Although the written report is not complete, it seems clear that in spite of these constraints an exciting series of missions is being proposed. If the SSEC core program is put into effect, we should see by the year 1985 launches (in addition to Galileo) of a Venus Radar Mapper, a Mars Geophysical/Climate Orbiter, and a rendezvous mission to the short-period Comet HMP. Under development would be additional missions to the moon, Titan, and a number of asteroids. The SSEC claims that these results can be achieved at a total cost (in current dollars) of \$300 million a year, only one third the budgetary levels of either the mid-1960's or the mid-1970's.

The first mission in the SSEC core program is a Venus Radar Mapper (VRM), designed to produce a topographic map with better than 1 km resolution—comparable to the achievements of the first Mars orbiter, which revolutionized our understanding of the geological history of that planet. VRM, one of four initiatives in the proposed fiscal 1984 NASA budget, is a scaled-down version of VOIR (Venus Orbital Imaging Radar), a mission deleted from the NASA budget in FY 82 by the Reagan administration. In a sense, VRM is archetypical of the SSEC missions, making maximum use of spare hardware and inherited designs, and carrying a modest science payload focused on specific, high-priority science and exploration goals.

During 1983 the SSEC will release its report on the core program and will go on to consider the more technologically challenging—and more expensive—missions that were excluded from its initial recommendations. Also, this group will be trying to make sure that as many people as possible are hearing its basic message that planetary exploration is not finished, and that numerous exciting missions are within our capability at relatively modest cost. If this message strikes a resonant chord among Washington decision makers, the United States will maintain its lead in planetary exploration through the 1990's.

This news item was contributed by David Morrison of the Institute for Astronomy at the University of Hawaii at Manoa.

Budget (cont. from p. 63)

lion would be allocated to the heart of the NOAA budget: Operations, Research, and Facilities; coastal zone management, previously a separate appropriation item, has been transferred into that category. Separate appropriations for miscellaneous "fishing funds" account for the remaining \$15.8 million.

The Operations, Research, and Facilities category is divided into five activities (Table 3), three of which are detailed in the following paragraphs.

Ocean and Coastal Programs

NOAA proposes to eliminate the Sea Grant activity. Within the nonliving marine resources subactivity, the polymeric sulfide program would be terminated and funds for deep seabed mining and ocean thermal energy conversion (OTEC) research would be reduced. The ocean research subactivity budget proposes an additional \$2.5 million is proposed to expand the ocean climate research program. Ocean research programs slated to end are the undersea research program, region-specific ocean pollution research, the Great Lakes research program (and with it, the closing of the Great Lakes Environmental Research Laboratory), and the Chesapeake Bay studies.

The budget for the ocean services subactivity requests an increase to cover the cost of producing publications on tides and currents; the entire cost of this program will be funded from appropriations and all receipts from the sale of the publications will be deposited to the Treasury Department. Decreases are proposed for the marine boundary program, for the marine current data collection program, and for the development of new technology in support of other ocean programs.

Within the coastal zone management subactivity, monies are requested to complete the phase out of the program. Decreases would eliminate the states' assistance program and would reduce funding to the estuarine sanctuary program.

Growth in the funding for the mapping, charting, and geodesy subactivity would help purchase additional receivers to use the Defense Department global positioning system. Funds also are requested for equipment to use interferometry techniques that aim to improve the efficiency of the geodetic reference system operations. The budget reduces technical support to state geodesy programs and eliminates plans for a geodesic survey of South Carolina.

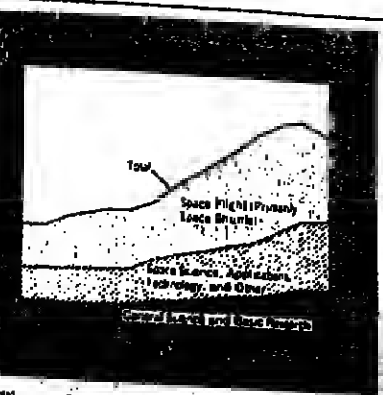
Atmospheric Programs

NOAA's atmospheric programs support weather prediction (including that of the National Weather Service), weather warning services, and associated research. Additional funds are requested to continue the NEXRAD program. Gains within the public warning and forecasting services would close the southern region headquarters; consolidate the Alaska and Pacific headquarters; and eliminate regional hydrological offices. The budget would shrink the fire weather program and terminate the agricultural weather, fruit frost, and aviation area forecast programs.

Increases would go to the atmospheric and hydrological research subactivity for research to improve prediction of severe weather and for investigations into seasonal climate forecasting using improved circulation theories. Decreases would go to weather-related systems development and hydrological research to state-specific weather modification activities, and to certain Global Atmospheric Research Programs (GARP) grants and projects. Proposed for elimination are all of the research and some of the services at the Solar Environmental Laboratory.

Satellite and Environmental Data

Satellite and environmental data information services is the only activity within NOAA Operations, Research, and Facilities that, as a whole, shows growth beyond inflation in the budget request. Most of this growth stems from transfers from NASA of LANDSAT and high-resolution scanner (thematic mapper) operations. Also covered under this category are programs associated with the procurement and operation of the polar and geostationary weather satellites and the collection, archiving, and dissemination of envi-



(Figure from The United States Budget in Brief: Fiscal Year 1984.)

Environmental Data and Information

The programs of the old National Environmental Satellite Service (NESS) and the old Environmental Data and Information Service (EDIS) are funded under this activity. In the satellite services subactivity, the budget allows the geostationary satellite additional funds so that its temperature and moisture sounding capability can be converted from a research prototype to an operational system. Under satellite services, the budget proposes to save money by consolidating satellite field service stations with weather service forecast offices in the same locale. This subactivity, which covers the procurement of satellite spacecraft, their launch, and associated ground systems, would receive additional money to store and check the LANDSAT D' satellite. The budget requests modifications of polar satellites that would allow their positioning in an orbit closer to noon to provide more useful information to the National Weather Service operational model. A decrease has been requested for a one-satellite polar-orbiting system.

Within the data and information services subactivity, the budget would reduce the climate data base effort, eliminate centralized NOAA publication functions, and end direct funding for the NOAA core library system. Of the 22 vessels that NOAA currently operates, 10 are proposed for deactivation. Two of these—the *Surveyor* and the *Ferris*—are research vessels; the rest are fisheries vessels. Five times as much is reduced for other research vessels.

NOAA anticipates a 19% reduction in staff in fiscal 1984; although some of this reduction will be through attrition, some may be through reduction in force (RIF).

USGS Funding Down

USGS funds will shrink 7% to \$365.5 million under the President's budget proposal. (The fiscal 1983 appropriation enacted to date is \$389.8 million; additions of roughly \$25.4 million in net transfers and requested 'supplementals' are anticipated.) Some of the decrease for fiscal 1984 is owed to the transfer of conservation of land and minerals activities to the Minerals Management Service.

Geologic and Mineral Resources

The largest USGS activity, Geologic and Mineral Resource Surveys, is budgeted for a 13.7% drop to \$141.9 million. The next largest, Water Resources Investigations, has been allocated \$112.1 million (down \$7.8 million). The National Mapping Program would receive \$77.9 million (down 11.9%) plus \$6 million (up 50%) for digital cartography; although part of the National Mapping Program, digital cartography activities have been proposed as an appropriation separate from the larger activity.

Geologic and Mineral Resource Surveys is divided into five subactivities. Within the mineral resource surveys subactivity, the budget gives \$9.3 million (an increase of nearly 60%) for the strategic and critical minerals program to enhance researching the mineral potential of the eastern and midwestern states. Within the geologic hazards subactivity the budget would cut the earthquake hazard reduction program (down 14.5% to \$29.5 million), volcanic hazards (down 32.1% to \$7.4 million), ground failure and construction hazards (down 25% to \$2.1 million), and reactor hazards research (down 46.9% to \$1.7 million).

Within the third subactivity, land resource surveys, the budget halves funds for the climate changes program to \$0.5 million. Although the land resource data application program is being eliminated, USGS says the activities will be conducted throughout the geologic research part of the agency. Within the energy geologic surveys subactivity, the state oil investigations program would be cut most deeply: down one third to \$0.6 million. Also scheduled for cuts are coal investigations (down 32.4% to \$9.8 million), uranium/thorium investigations (down 27.3% to \$3.2 million), and geothermal investigations (down 27.4% to \$5.3 million). The fifth subactivity, offshore geologic surveys, would maintain the fiscal 1983 budget of \$13.7 million for the offshore geologic framework program.

Water Resources

Under the Water Resources Investigations activity, funds for the toxic waste-ground water contamination program would rise 16.4% to \$7.1 million, while acid rain program funding would increase to \$3.1 million (up 19.2%). Under the energy hydrology subactivity, funding for coal hydrology would be chopped 71.4% to \$2 million, and funding for oil shale hydrology would drop 76.9% to \$0.5 million. The program for analyses of regional aquifer systems would drop 8.6% to \$14.0 million, while the environmental affairs program would fall by one fifth to \$0.5 million. The budget eliminates the flood hazard analysis program and, although the data base for the water resources scientific information center will be maintained, the center's funding has been wiped out. Programs suggested for level funding include national water data activities, core program hydrologic research, improved instrumentation, water resources assessment, and coal hydrology (within the

TABLE 3. Appropriations for NOAA Operations, Research, and Facilities

Program	FY 1983 Base	FY 1983 Estimate	% Difference
Ocean and coastal programs	148,715	147,125	-1.1
Nonliving marine resources	3,432	3,432	0
Ocean research	35,431	35,152	-0.8
Ocean services	15,141	15,237	0.6
Sea Grant	35,000	0	-100.0
Coastal zone management	14,226	6,076	-57.3
Mapping, charting, and geodesy programs	15,289	72,619	470.4
Marine fishery resource programs	146,191	142,411	-2.6
Information collection and analyses	75,019	55,732	-25.0
Conservation and management operations	55,506	33,166	-39.7
State and industry programs	15,436	3,226	-78.4
Atmospheric programs	321,263	309,187	-3.8
Public warning and forecasting services	272,221	261,936	-3.7
Atmospheric and hydrologic research	19,042	11,561	-39.3
Satellite and environmental data and information services	198,756	212,953	7.2
Satellite services	85,017	71,279	-16.0
Satellite systems	103,500	117,461	13.5
Data and information services	25,639	22,313	-13.0
Program support	115,813	95,353	-17.7
Executive direction and administration	51,150	11,748	-77.1
Marine services	57,493	16,525	-71.2
Aircraft services	4,180	1,380	-67.2

Data from NOAA. In thousands of dollars.

1984 base reflects fiscal 1983 operations, research, and facilities funding levels plus adjustments to base for such items as the proposed 1983 program supplemental, anticipated 1983 pay increase supplemental, and annualization of LANDSAT operations and reflects transfers such as those for coastal zone management and the coastal energy impact fund.

subactivity called national water data system: federal-state cooperative program).

The only initiative within the USGS budget request for fiscal 1984 falls within the purview of the National Mapping Program. With a \$1 million budget, the new federal mineral land information program aims to provide a computerized data base to answer questions on federal land ownership and mineral occurrence data.

Rounding out the USGS budget are the requested appropriations for facilities (\$13.2 million, which is no change from the current fiscal year) and for general administration (planned \$1.3 million to \$1.2 million). The USGS expects that the number of full-time equivalent staff members will drop through attrition nearly 5% to 7,587 in fiscal 1984.

NASA Nudges Inflation

Monies requested for NASA in the fiscal 1984 budget total \$7.1 billion. This increase of \$267.2 million or 3.9% over fiscal 1983 means that NASA only edges up to the projected 5% inflation rate. (Growth within NASA's programs will be higher, though, because most of the funds for LANDSAT, previously operated by NASA, now are included in the NOAA budget.) Research and development, which accounts for roughly 80% of NASA's total budget, would increase 3% to \$5.7 billion; the request for construction of facilities would increase 5.4% to \$150.5 million, while research and program management would climb 4% to \$1.2 billion.

This is a constrained budget consistent with the serious fiscal and budgetary situation facing the nation, commented NASA Administrator James M. Beggs. "Nevertheless, it reflects the President's renewed commitment to a strong national space and aeronautics program as outlined in his two important policy statements on space and aeronautics last year."

NASA's research and development falls into five categories: space transportation systems, space science and applications, technology utilization, aeronautics and space technology, and tracking and data acquisition. Roughly 60% of the research and development budget would go to space transportation systems, including production and operation of the space shuttle. The allocated funds from nearly \$3.5 billion, a 2.8% decrease from fiscal 1983. The majority of the money was cut from space transportation capability development. NASA administrators say that there are no plans for a fifth shuttle orbiter. However, included in the budget request is hardware development for the Tethered Satellite System, one of four new starts in the NASA budget. A cooperative U.S.-Italian project, the new system would permit experiments in space at distances up to 100 km from the shuttle orbiter.

Space Science and Applications

Space science and applications is the second largest of NASA's R&D programs and contains most of NASA programs tied directly to geophysical research. Programs in physics and astronomy would receive \$514.6 million, an increase of 16.7% from fiscal 1983; life sciences would get \$69 million (up 6.9%); solid earth observations would decrease to \$74.4

million (down 43.7%) with the transfer of LANDSAT operations to NOAA; environmental observations would increase to \$383 million (up 3.2%); materials processing in space would lose \$409,000 (1.8%); communications would decrease to \$21.1 million (down 34.9%); and information systems would receive \$8.9 million (up 18.7%). The communications program includes startup of design and development for the Advanced Communications Technology Satellite (ACTS) project. ACTS, budgeted for \$5 million in fiscal 1984 (plus \$20 million earned forward from fiscal 1983), aims to develop and perform in-flight tests of the high-tech technology needed to ensure continued United States preeminence in the field of satellite communications, according to NASA Administrator Beggs. Costs for ACTS will be shared with industry.

Programs in planetary exploration, also within space science and applications, would increase 10.2% to \$215.4 million in the Reagan budget proposal. The Venus Radar Mapper (VRM) Mission, a new start in this category, would receive \$23 million. VRM replaces the Venus Orbiting Imaging Radar (VOIR) mission that was authorized by Congress in fiscal 1982. Total costs for VRM are expected to be half the estimated costs of VOIR. Development of the Galileo mission would be allocated \$77.5 million, a decrease of 13.2% from the current fiscal year and research and analysis would decline 9.2% to \$15.5 million. Mission operations and data analysis would increase 12.7% to \$14.4 million, while the International Solar Polar Mission would get \$8 million, up from \$6 million.

Within environmental observations programs, funds for the shuttle and Spacelab payload development would jump 105.4% to \$7.0 million and funding for upper atmosphere research, satellite experiments and balloon definition would grow by 42.9% to \$20 million. The impact decreases were proposed to the operational satellite improvement program (down 50% to \$300,000) and to the earth radiation budget experiment (down 35.4% to \$15.5 million).

Aeronautics and Space Technology

Aeronautics research and space technology (funded at \$438.3 million in fiscal 1984, up 8.8%) would have as its centerpiece the National Aerodynamic Simulation (NAS) capability project. NAS, a large computer system, would have a major impact on aircraft design methods, improving accuracy and reliability, while at the same time, cutting down on long and expensive wind tunnel and flight testing, according to Beggs. NAS, one of the four NASA initiatives, is budgeted for \$20 million in the fiscal 1984 budget.

Of the remaining two categories within NASA research and development, funds for tracking and data acquisition would increase 40.3% to \$700.2 million and technology utilization would drop 55.6% to \$4 million. Of the funds allocated for construction of facilities, the largest amounts would go to the Lewis Research Center (\$10.6 million), the Langley Research Center (\$9.5 million), and the Jet Propulsion Laboratory (\$4.5 million). In addition, the budget allocates \$41.5 million to the various space shuttle facilities and \$12 million to various space shuttle payload facilities.—BTR

Solitary Waves As Aviation Hazard

Scientists at the Australian National University in Canberra have found that wind shear produced by solitary atmospheric waves is a potentially serious hazard to aircraft operating at low altitudes. In recent years a significant number of aircraft accidents have been attributed to a sudden, unexpected encounter with low-level wind shear during the landing or takeoff stage. In many cases it has been possible to associate the hazardous shear with one of a variety of well known meteorological wind shear conditions including intense thunderstorm down drafts, down-draft produced density currents, cold frontal systems, and sea breezes. These sources are easily recognized and are usually predictable in the airport environment. In some instances, however, the identity of the wind shear source has been uncertain. Studies of the properties of large amplitude solitary waves in the boundary layer have shown that they produce intense, transient, horizontal and vertical wind shears which are comparable with the well known types of shear. Solitary wave activity may therefore account for some hitherto unexplained aircraft accidents.

Until recently, solitary waves were regarded as a curious but relatively unimportant dynamical phenomenon. It is now recognized that these waves are exceptionally stable entities that play an important role in the dynamics of geophysical fluid systems. Internal soli-

tary waves, or solitons, occur frequently in the upper layers of the ocean and in inland lakes and fjords. They are also a dynamical feature in the Martian atmosphere.

The first definitive observations of solitary waves in the lower troposphere were made in 1976 at the Warrnambool Infrasonic Array located near Tonnant Creek in the arid interior of Australia's Northern Territory. These observations have since been extended through the use of portable microbarometer arrays to determine the coherence and evolution of nonlinear wave disturbances as they propagate over the northern Australian region. Perhaps the most important result of this detailed study is the recognition that solitary waves are a commonly occurring, ubiquitous component in the dynamics of the lower atmosphere. Nonlinear waves of this type are by no means unique to northern Australia. Large-amplitude solitary waves may be expected to occur wherever conditions of low-level stability prevail, and thus they should be regarded as a significant, world wide hazard to aviation.

Solitary waves in the lower atmosphere take the form of isolated, single-crested waves of elevation which propagate predominantly as clear-air disturbances in a boundary layer inversion waveguide. They are produced quite naturally in the asymptotic decay of any large

amplitude, long-wave disturbance. Under conditions of high humidity such as those sometimes found in maritime areas they may be accompanied by a low-level, propagating roll cloud formation. The 'Morning Glory' of the Gulf of Carpentaria (see cover) is a spectacular example of a visible manifestation of a solitary wave. Cloud formations of this type are relatively rare, however, and are seldom seen in inland regions. It concerns aviation greatly that even in coastal areas these large amplitude waves usually recur without warning as sudden clear-air disturbances.

Solitary waves in the lower atmosphere often exhibit closed circulation in the relative streamline flow pattern. Winds near the surface in these horizontal propagating vortices exceed the speed of propagation and may present a particularly severe hazard to aircraft operating at low altitudes. The leading up-draft and trailing down-draft in atmospheric solitary waves may exceed 8 m s⁻¹. Maximum horizontal winds occur at the center of the wave near the surface and their speeds typically range from 10 to 15 m s⁻¹, although occasionally they may be much higher.

These transient horizontal and vertical wind shears can affect the performance of aircraft in a variety of ways. Perhaps the most serious situation occurs when an aircraft en-

counters a solitary wave from the front during final approach. In this case the aircraft will first rise above the glide path under the positive influence of increasing head-winds and up-draft. The normal reaction of a pilot in this situation will be to decrease thrust or increase drag in an attempt to return the aircraft to the standard glide path. This action combined with the sudden loss of lift along the trailing edge of the wave due to decreasing head-winds and down-draft could lead the aircraft dangerously close to the ground and well short of the runway threshold. Conversely, runway overshoot is produced by solitary waves propagating along the direction of flight.

The study of atmospheric solitary waves during the coming year will focus primarily on the specific meteorological factors which lead to their production and long-range propagation. An investigation of the wind shear hazard posed by these waves to aviation in the Australian region has been completed. Detailed findings have been sent to all authorities concerned with air safety and an article on the subject by D. R. Christie and K. J. Muirhead will appear in *Aust. Met. Mag.*, 31, 1983.

This news item was contributed by D. R. Christie of the Research School of Earth Sciences, The Australian National University, Canberra.

Books

Tectonophysique et Géodynamique: Une Synthèse Géologie Structurale-Géophysique Interne

L. Liboutry, Masson, Paris, France, 339 p., 1982.

Reviewed by Xavier Le Pichon

Liboutry is an imaginative physicist with a vast scientific knowledge. On most problems that he discusses, he likes to formulate his own solutions, and he formulates them with frankness and, often, abruptness. I was, thus, curious to read his new textbook, which is for geologists as well as geophysical university students.

I must say that I was not disappointed. This is an original and interesting book, and I know of no equivalent. It has an excellent table of contents: earthquakes and structure of the earth; earth magnetic field; remanent magnetization; seafloor spreading; subduction; present plate kinematics; past plate kinematics; nature of crust and mantle; isostasy; low velocity zone, and heat flow; vertical motion; elastic and plastic deformations and ruptures; mechanical properties of plates and mantle; nature of lower mantle and differentiation of crust and hot spots; driving mechanisms; tectonic mechanisms; and orogenesis. There is a limited amount of mathematics. Consequently, geologists should not find it too hard reading, although the demonstration of the validity of any geology or geophysics is assumed. References are given in an abbreviated form within the text, and there is a combined subject-author index. The book is well illustrated, mostly with generally well-chosen figures from major papers.

This is a physicist's book. Liboutry tries to discuss the physical processes behind the major geodynamic phenomena and to show that many popular theories have fairly weak bases. This often leads him to propose new ideas or hypotheses, sometimes controversial and based on his own prejudices; for example, he insists on a high 10²⁵ P viscosity lower-mantle against most recent evidence. In detail, I have found many points where I disagree and a few that are simply not correct. For example, his summary on the present evidence on the viscosity of the present mantle is biased and does not do justice to the work of Pelletier and his collaborators (p. 242). There is no Figure 5-13 (p. 52). He considers guyots and seamounts as synonyms (p. 57). He states that the quasi-totality of the earth volcanisms occurs along subduction zones which ignores all the mid-oceanic underwater volcanism (p. 249). He states that most of the sediments in 'eugeosynclinal' settings are of deep oceanic basin origin and have been piled up in the subduction zone by accretion, ignoring the importance of locally derived arc sediments (p. 307). He proposes for the Messinian Mediterranean evaporite layer a deep basin origin and compares 'un' (sic) its formation to the formation of the present Red Sea hot brines, which is not compatible with recent geologic evidence (p. 329). And, this list is far from exhaustive.

But these are relatively minor points within this well-constructed and highly readable book. To get its flavor, it may be best to quote Liboutry on geosynclinal tectonics, which he finds 'confused, useless and dangerous' or on the notion of orogenic cycle, which he attributes to the persistence during a long period, of the order of 100 M.Y., where (two

continents have been colliding, of a thin lithosphere which reaches the plasticity threshold at each orogenic phase. This is indeed the main conclusion of this book, which integrates in a satisfactory way continental deformation within a broad plate tectonic framework. Its reader progressively realizes that the geodynamic evolution of the surface of the earth is controlled by the mechanical properties of the plates which, unfortunately, are still poorly known, although we do know a great deal more than a few years ago.

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Causes and Effects of Stratospheric Ozone Reduction: An Update

Committee on Chemistry and Physics of Ozone Depletion and the Committee on Biological Effects of Increased Solar Ultraviolet Radiation, National Academy Press, Washington, D.C., xi + 339 pp., 1982, \$19.95.

Reviewed by Guy Brasseur

In 1976, the National Academy of Sciences released a report entitled *Haloalkanes: Effects on Stratospheric Ozone*. The purpose of this study was to evaluate the likely effect of chlorofluorocarbons (CFCs) on the ozone layer in the atmosphere.

A number of publications on the same subject have been prepared since then by different official bodies (NASA, World Meteorological Organization, European communities, the British government, etc.). The opinions expressed in these reports were not always in agreement and even sharply differed in certain cases.

More recently, at the request of the U.S. EPA and in accordance with the Clean Air Act, as amended in 1979, the National Research Council has provided an assessment of the state of knowledge on ozone depletion and its effects on public health and welfare. The report whose purpose is to assess the most recent scientific information has been published by National Academy Press.

The report is divided into two parts. The first part, prepared by the Committee on Chemistry and Physics of ozone depletion chaired by Charles H. Kruger, Jr., reviews the processes determining the ozone concentration including the perturbations by chlorine, oxides of nitrogen, and other species. It describes the current status of stratospheric models and discusses our ability to detect trends in ozone in relation with any anthropogenic action.

In its conclusion, the first part of the report states that "if the production of CFCs continues into the future at the rate existing in 1977, the steady state reduction in total ozone, in the absence of other perturbations, would be between 5 and 9 percent." These numbers are lower than previous estimates, which shows the necessity of updating frequently our knowledge in stratospheric chemistry. The report also indicates that "on the whole there have been substantial improvements in the agreement between model predictions and observed profiles of trace species." There are a few exceptions, however, and, since the uncertainties can be hardly quantitatively estimated, it is suggested that "the discrepancies should be resolved in the future by an orderly application of the scientific method with appropriate interaction between theory and observation." Finally, the problem of simultaneous perturbations is considered. Ozone may be altered not only by CFCs but also by an increasing emission level.

of nitrogen oxide in association with agricultural practices, disposal of human and animal wastes, and possible combustion. Moreover, the corresponding ozone reduction might be partly offset by the increased concentration of carbon dioxide or methane. It is therefore recommended (1) to maintain a coordinated research program to understand the spatial and temporal distribution of the key trace species including atmospheric observation, laboratory measurements, and theoretical modeling; (2) to monitor ozone, water vapor, and temperature, using both satellite and ground-based systems; and (3) to assess the consequence for stratospheric ozone of the emission in the atmosphere of all relevant gases such as CFCs, and CH₄, CH₃Cl, CH₃Br, N₂O, CO₂, and H₂. Other vehicles such as balloons and aircraft will also contribute to this task.

The text devoted to the chemistry and the physics of ozone depletion is very clear and well written. It is based on six papers provided by six consultants and published as appendices: (1) Perturbations of the Stratosphere and Ozone Depletion, by R. J. Ciccone; (2) Stratospheric Perturbations—the Role of Dynamics Transport and Climate Changes, by R. E. Dickinson; (3) Recent Developments in Stratospheric Photochemistry, by S. G. Wofsy and J. A. Logan; (4) The Measurement of Trace Gaseous Species in the Stratosphere: A Review of Recent Results, by J. G. Anderson; (5) Trend Analysis of Total Ozone, by H. A. Panofsky; and (6) Detection of Trends in the Vertical Distribution of Ozone, by A. B. Pittcock.

The length of the six appendices is quite disproportionate, which reduces the overall coherence of the text. However, these individual contributions are very readable and contain much useful information. The reader particularly interested by these questions should also refer to the report published by WMO and entitled *The Stratosphere 1981: Theory and Measurements*.

The second part of the report is devoted to the biological effects of increased solar ultraviolet radiation. It has been drawn by a committee under the chairmanship of R. B. Setlow. Three topics are covered: (1) molecular and cellular studies, (2) ecosystem effects, and (3) human health effects. It is concluded that DNA is probably the primary target in animal cells for most deleterious effects of UV-B and that the major injury to DNA appears to be the formation of pyrimidine dimers which distort the normal DNA helical structure. Both UV-A and UV-B are also detrimental to plant growth, but the adaptability of plant species appears to be sufficient to maintain food crop yields. UV-B radiation can also damage aquatic organisms, but there is no information to predict the magnitude of such adverse effects.

The relationship between increased solar radiation and the appearance of skin cancers has been widely discussed in recent years since more than 90% of skin cancers other than melanoma seem to be attributable to sunlight. The report states that a 1% increase in UV-B would give a 1-2.5% increase in basal cell skin cancers and a 2-5% increase in squamous cell skin cancers. The appearance of skin melanoma is partly due to sunlight but probably also to other factors. A prediction of enhanced incidence due to increased exposure to UV can therefore not be made. Models of light-induced melanomas are required together with epidemiological studies based on clinical and histological studies.

In summary, the report accomplishes its intended purpose quite well. It should give the policy makers a good assessment of our present knowledge and of the uncertainties on the causes and effects of ozone depletion.

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AGU to Revise Journal Index Terms

AGU is revising its set of indexing terms. If you have suggestions or comments, please contact the appropriate Journals Board member, AGU Journal Editor, or Associate Editor by February 23, 1983. AGU proposes to coordinate its index with a revision of the AIP/APS-PACS index scheme (*Phys. Rev. Lett.*, 48, 1, 1982) (see *Eos*, February 8, 1983).

Cover. Approaching low-level roll cloud formation produced by a solitary wave propagating in a maritime inversion toward the southwest over saline coastal flats near Burketown, Queensland, shortly after sunrise on October 1, 1981. Spectacular propagating roll cloud formations of this type are observed with some regularity during September and October along the tropical southern margin of the Gulf of Carpentaria, where they are known as the 'Morning Glory.' The base of the cloud is estimated to be about 0.5 km and the top lies at about 1.5 km. The position of the cloud line marks a complex localized region of intense vertical and horizontal wind shear near the surface. The motions of the cloud elements in the strong up-draft along the leading edge and down-draft along the trailing edge combine to give the visual impression that the cloud line is rolling backward as it propagates. Solitary waves are only rarely observed as visible, propagating roll clouds. They usually occur as sudden, unexpected, clear-air disturbances which represent a potentially serious wind shear hazard to aircraft (especially jet aircraft, with their relatively slow response) during landing and takeoff. (Photo courtesy of D. R. Christie)

